



Length-Weight Relationships of Six Fish Species of a Rocky Intertidal Shore on the Subtropical Atlantic Coast of Spain

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Received: 11 June 2020 / Revised: 2 December 2020 / Accepted: 7 December 2020 / Published online: 6 January 2021
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Abstract

Length-weight relationships (LWRs) for six fish species caught from tidepools in an intertidal rocky shore in the Gulf of Cadiz are presented. This study presents the first data on LWR for *Clinitrachus argentatus* ($WT = 0.0069 * TL^{3.077}$), *Coryphoblennius galerita* ($WT = 0.0051 * TL^{3.409}$), and *Parablennius incognitus* ($WT = 0.0090 * TL^{3.113}$) outside the Mediterranean Sea and adjacent eastern waters. The data of LWRs for juveniles of *Symphodus roissali* ($WT = 0.0117 * TL^{3.091}$), *Serranus scriba* ($WT = 0.0165 * TL^{2.881}$), and *Diplodus cervinus* ($WT = 0.0152 * TL^{3.060}$) are also presented for first-time. Due to fish body shape may vary during growth in relation to size, studies covering a specific size range relating to life stage can be useful to estimate the LWRs for different development phases. The findings of this study fill the gap in LWRs data for immature fish in *S. roissali*, *S. scriba* and *D. cervinus*. Moreover, because intertidal zones and their adjacent subtidal areas represent nursery grounds for species that eventually recruit to coastal fisheries, the LWRs estimates for other species can also help to understand the population dynamics and conservation for native fish species.

Keywords Length-weight relationships · Intertidal fish · NE Atlantic

Introduction

Intertidal fish species are difficult to study because of their cryptic nature (Bogorodsky et al. 2010). Fish species are categorized by their degree of residency in pool habitats as permanent residents (those that remain within the intertidal zone for their entire lives) or secondary residents (those that spend only a part of their life history in this habitat, mostly as juveniles) (Griffiths 2003). Although they have little commercial value, accurate estimation of their biomasses is crucial because intertidal zones and their adjacent subtidal areas represent nursery grounds for numerous species that eventually

recruit to coastal fisheries (Ribeiro et al. 2012). Consequently, knowing the length-weight relationships (LWRs) of intertidal fish species will be useful to convert length observations, for example, obtained from underwater visual census methods, into weight estimates for biomass evaluations (Parker et al. 2018). Therefore, it can contribute on species conservation and fisheries management (Evangelopoulos et al. 2020). However, due to the sampling procedure should be standardized to be able to compare the LWRs parameters among studies (Compaire and Soriguer 2020), the site-specific LWRs data are required to an accurate estimate of biomass in a region.

The condition factor and relation of body proportion can be used to indicate the condition of a fish or even to identify subpopulations of a species (Wootton 1998; Jones 2002). LWRs studies often evaluate the entire length distribution range of species (e. g. Parker et al. 2018, Compaire and Soriguer 2020), however, condition factor and fish body shape may vary during growth in relation to size (Santos et al. 1996; Evangelopoulos et al. 2020). The present study partly addresses this concern evaluating the LWRs in a narrow length range for six fish species collected from an intertidal rocky shore. *Coryphoblennius galerita* and *Clinitrachus argentatus* have not been described in the literature yet. First records for *Parablennius incognitus* in Atlantic waters, as well as for

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juveniles of *Symphodus roissali*, *Serranus scriba* and *Diplodus sargus* are also presented here. Due to intertidal fish species are useful as ecosystem health biomonitors, since its absence may indicate anthropogenic stresses or recent disturbance (Barrett et al. 2015), the information about growth for these species can be used to assist for the management of the natural park La Breña y Marismas del Barbate (located close to our sampling site) as well as to comply the goals of the European Water Framework Directive (2000/60/EC) (WFD 2000), which comprises an assessment of the ecological status of coastal waters, including rocky intertidal communities of the North-Eastern Atlantic where these fish species inhabit.

Materials and Methods

Tidepools were sampled monthly from April 2008 to January 2012 at Caños de Meca intertidal rocky shore (36° 11' N – 6° 01' W) in the Gulf of Cadiz, Spain (Fig. 1). This location has many pools with similar substratum topography throughout

the year. Boulders, sandy patches and algae are often found in these pools (Compaire et al. 2019). 50 intertidal pools were sampled during the sampling period. The area of the pools was on average (\pm S.D.) 16.7 ± 13.9 m², depth was 10.4 ± 3.78 cm, and the volume was 1536 ± 834 l. Fish were collected using natural clove essential oil as an anaesthetic (Griffiths 2000) and hand nets (mesh size: 1.5 mm). Clove oil and hand nets are a traditional method of sampling intertidal fish that allows catching specimens on a broad range of sizes (Velasco et al. 2010; Compaire et al. 2018a, b). Fish were kept on buckets with dry ice until being moved to the laboratory. Once there, specimens were identified to species level according to the descriptions of Whitehead et al. (1986), and the total body length (TL) and total body weight (WT) of each specimen were measured with an accuracy of 0.1 cm and 0.01 g, respectively. These authors also reported the most common habitat for these species. So, according to their utilisation of rocky intertidal zone, fish species were classified as permanent residents (species belonging to Blenniidae and Clinidae families)

Fig. 1 Study area in the eastern Gulf of Cadiz, Spain. Black square indicates the sampling site, Caños de Meca

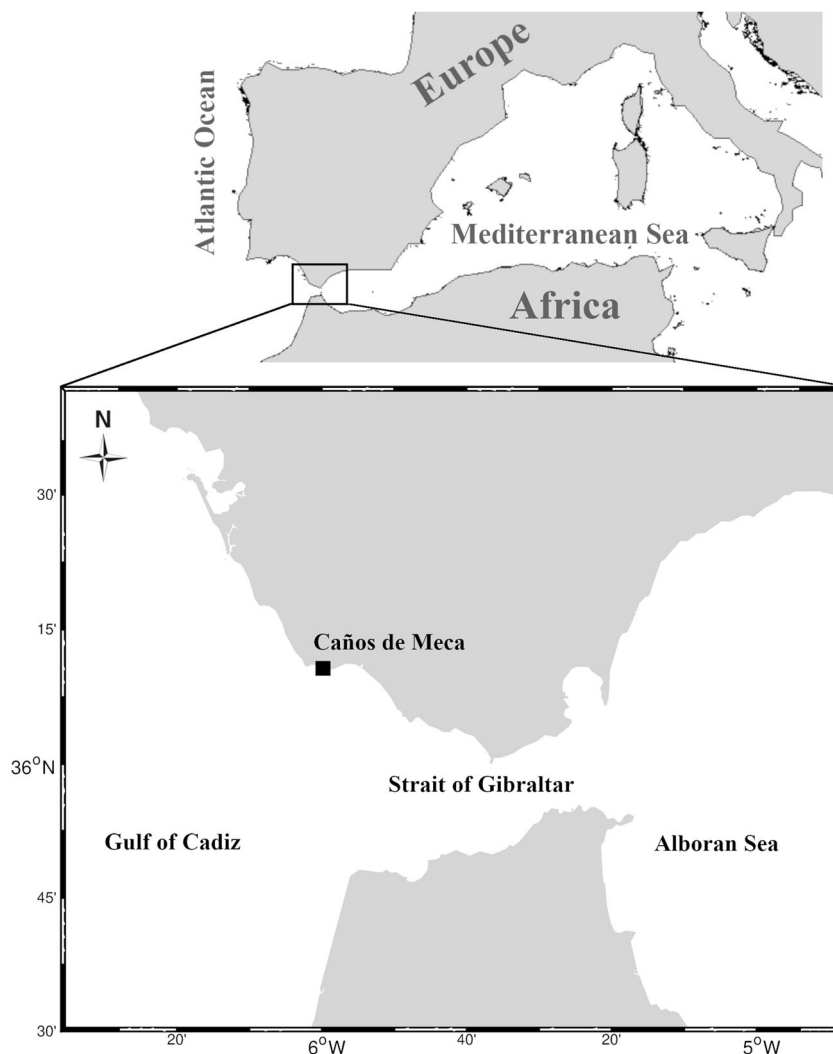


Table 1 Length-weight relationships for six fish species caught in the pools of the rocky intertidal zone at Caños de Meca (Gulf of Cadiz, Spain)

Family - species	n	TL (cm) min-max	WT (g) min-max	a (95% CI)	b (95% CI)	r^2
Blenniidae						
<i>Coryphoblennius galerita</i> (Linnaeus, 1758)	4	3.0–5.2	0.20–1.42	.0051 (.0023–.0116)	3.409 (2.834–3.984)	.997**
<i>Parablennius incognitus</i> (Bath, 1968)	22	3.6–5.6	0.45–1.78	.0090 (.0062–.0129)	3.113 (2.864–3.363)	.971***
Clinidae						
<i>Clinitrachus argentatus</i> (Risso, 1810)	51	3.5–5.9	0.33–1.41	.0069 (.0040–.0117)	3.077 (2.723–3.430)	.862***
Labridae						
<i>Symphodus roissali</i> ⁺ (Risso, 1810)	103	2.4–10.8	0.20–19.22	.0117 (.0103–.0133)	3.091 (3.016–3.166)	.985***
Serranidae						
<i>Serranus scriba</i> ⁺ (Linnaeus, 1758)	17	5.2–7.6	1.95–5.66	.0165 (.0094–.0290)	2.881 (2.580–3.181)	.963***
Sparidae						
<i>Diplodus cervinus</i> ⁺ (Lowe, 1838)	10	3.7–6.7	0.88–4.96	.0152 (.0081–.0287)	3.060 (2.665–3.456)	.976***

n: number of specimens; TL: total length in cm; WT: total body weight in g; a and b are the intercept and slope of length-weight relationship, respectively; r^2 is the coefficient of determination for the regression on logarithms. ** $p < .01$, *** $p < .001$. ⁺ Juveniles only

and secondary residents (species belonging to Labridae, Serranidae and Sparidae families).

The parameters of length-weight relationship $WT = aTL^b$ were estimated by least-squares linear from the log-transformed equation regression: $\log WT = \log a + b \log TL$, where a is the intercept and b is the slope. The 95% confidence intervals (CI) of parameters a and b were estimated, and coefficient of determination (r^2) was calculated to evaluate the fit of the model. A scatter plot of length-weight relationships for each species was done. Limits to draw the curves were established for each species, asymptotic length for permanent residents, length at first maturity for *S. roissali* and 10 cm for *D. cervinus* and *S. scriba*. Logistic functions were used to estimate the asymptotic length and the length at first maturity for each species (Froese and Binholan 2000). The maximum length necessary to determinate the asymptotic length was obtained from a previous study carried out in another intertidal rocky shore in the Gulf of Cadiz for permanent resident species (Velasco et al. 2010), and from global data bank FishBase (Froese and Pauly 2019) for secondary residents species. LWRs and statistical analyses were performed with R software (R Core Team 2020), while LWRs plots were drawn using Matplotlib Python module (Hunter 2007).

Results

In this study, we measured total length and weight for 207 specimens, belonging to 6 fish species and 5 families. The length at first maturity calculated for each species allowed us

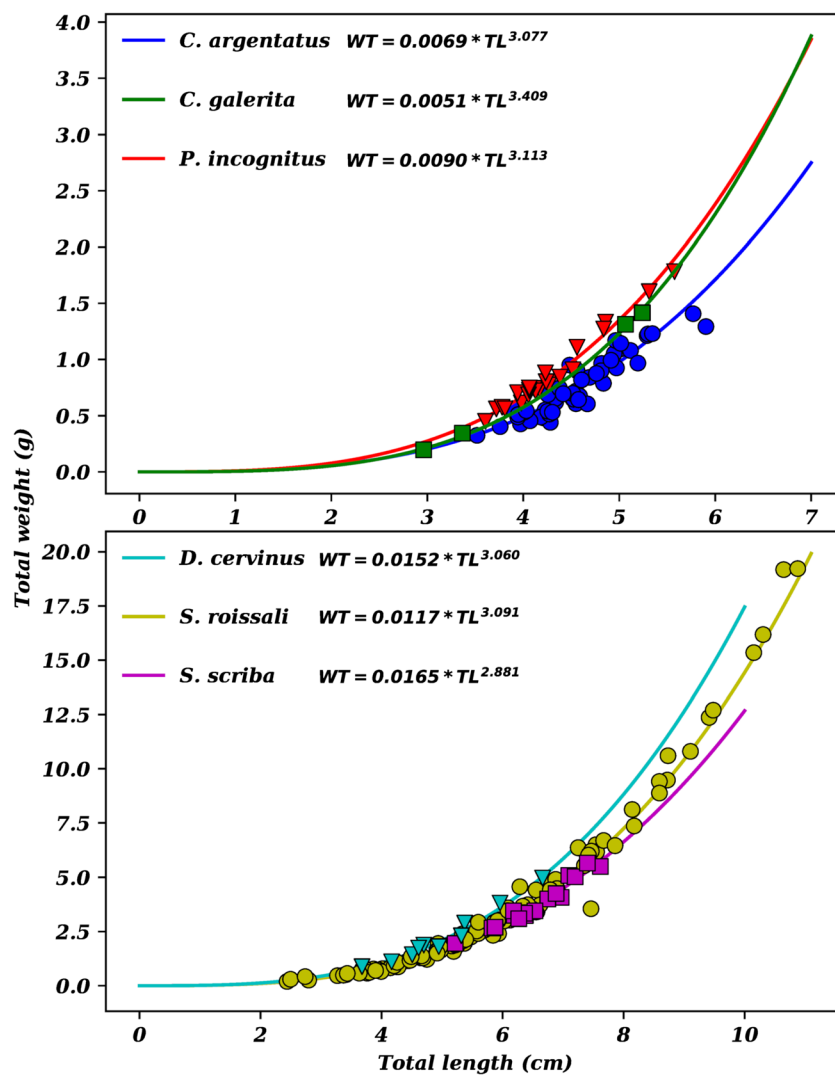
to determinate that all secondary residents' specimens were juveniles, while permanent residents also included adults. The number of specimens measured, size range, length-weight relationships with accompanying 95% confidence intervals, and the coefficient of determination for the six fish species analysed are shown in Table 1. All regressions were significant ($p < 0.01$), with the coefficient of determination ranging from 0.862 to 0.997. Blenniidae species showed positive allometric growth ($b > 3$). Only juveniles of *S. scriba* showed negative allometric growth ($b < 3$). An isometric growth was observed for *C. argentatus* and juveniles of *S. roissali* and *D. cervinus*. The LWRs curves are shown in Fig. 2.

Discussion

Although more fish samples should be collected to reduce for uncertainty resulting from insufficient sample sizes, the values of b parameter remained within the expected range of 2.5–3.5 (Froese 1998) for all species. Due to most fishes will change their shape as they grow (Martin 1949), it must be stressed the parameters obtained for species belonging to Labridae, Serranidae and Sparidae families have to be treated with caution since all the specimens analysed were juvenile, and consequently, the parameter b can show differences according to the life-history stage.

According to the global data bank FishBase (Froese and Pauly 2019), no LWR information is available for *C. argentatus* and *C. galerita*. Before comparison our LWR parameters with those obtained by previous studies, we must

Fig. 2 Length-weight relationships for a) *Clinitrachus argentatus*, *Coryphoblennius galerita* and *Parablennius incognitus*, and b) *Diplodus cervinus*, *Symphodus roissali* and *Serranus scriba*. Curves are plotted up to the asymptotic length for permanent residents, length at first maturity for *S. roissali* and 10 cm for *D. cervinus* and *S. scriba*



take into account that i) particular food web or environmental conditions at each location will affect growth rates, and ii) fishing methods can be different and hence differences among them will be not surprising, actually, these discrepancies will be expected. The b value obtained for *P. incognitus* ($b = 3.113$) is slightly higher than reported for specimens caught using various fishing gear (beach-seine, fyke-net, gill nets) at different estuarine systems in Greece ($b = 3.060$; Koutrakis and Tsikliras 2003). Regarding the juveniles, the b values for *S. roissali* (3.091) and *S. scriba* (2.881) lie within the range of previous studies carried out mainly in the Mediterranean Sea and eastern adjacent waters, which collected fish coming from various fishing gear. In the case of the former, specimens were obtained from by-catch of commercial landings, spear-fishing and beach-seine ($b = 2.670$, Gordoa et al. 2000; $b = 3.386$, Keskin and Gaygusuz 2010). While for the second one, the lowest ($b = 2.715$, Abdel-Aziz 1991) and highest ($b = 3.409$, Sangun et al. 2007) values were obtained from fish

caught by trawl and longlines. Lastly, our result about the positive allometric growth for *D. sargus* juveniles ($b = 3.060$) agrees with preceding studies that used longlines, gill and trammel nets to capture adults of this species in the south of Portugal ($b = 3.140$, Gonçalves et al. 1997) and France ($b = 3.28$, Crec'hriou et al. 2012).

In spite of the results of this study are limited to the length ranges presented for each species, Froese (2006) recommends the estimation of separate LWRs for different development phases, thus our findings are valuable to evaluate the LWRs in immature fish in *S. roissali*, *S. scriba* and *D. cervinus*. On the other hand, the results for other species present for first-time local information about the parameters of LWRs, which can contribute to the management and conservation for native fish populations and fisheries.

Acknowledgments We are grateful to M. Florio and three anonymous reviewers for helpful comments on the manuscript.

Availability of Data and Material Data are available on reasonable request from the corresponding author.

Authors' Contributions Milagrosa C. Soriguer designed the research. Carmen Gómez-Cama, Milagrosa C. Soriguer and Jesus C. Compaire were involved in the sampling surveys. Carmen Gómez-Cama and Jesus C. Compaire identified and processed the fish caught. Milagrosa C. Soriguer and Jesus C. Compaire analysed the data and performed the statistical analysis. Jesus C. Compaire interpreted the results and wrote the manuscript, and Milagrosa C. Soriguer contributed to the revision of it.

Compliance with Ethical Standards

Conflicts of Interest/Competing Interests No financial conflict of interest was reported by the authors.

Ethics Approval Fish specimens were appropriately sedated to ensure animal welfare and avoid needless pain before they were killed. This methodology complied with regional animal welfare laws, guidelines and policies as approved by the Territorial Delegation of Agriculture, Fisheries and Environment of the Regional Government of Andalusia.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

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